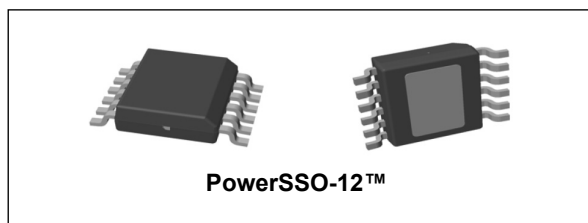


Dual high side smart power solid state relay

Datasheet - production data



Features

- Nominal current: 0.5 A per channel
- Shorted-load protections
- Junction overtemperature protection
- Case overtemperature protection for thermal independence of the channels
- Thermal case shutdown restart not simultaneous for the various channels
- Protection against loss of ground
- Current limitation 1 A per channel
- Undervoltage shutdown
- Open-load in off-state and short to V_{CC} detection
- Open-drain diagnostic outputs
- 3.3 V CMOS/TTL compatible inputs
- Fast demagnetization of inductive loads
- Conforms to IEC 61131-2

Description

The VNI2140J is a monolithic device designed using STMicroelectronics' VIPower technology. The device drives two independent resistive or inductive loads with one side connected to ground. Active current limitation prevents a drop in system power supply in cases of shorted-load, and built-in thermal shutdown protects the chip from damage due to overtemperature and short-circuit. In overload conditions, channel turns OFF and ON automatically to maintain the junction temperature between TTSD and TR. If the case temperature reaches TCSD, the overloaded channel is turned OFF and restarts only when case temperature decreases down to TCR. In order to avoid high-peak current from the supply, when more than one channel is overloaded the TCSD restart is not simultaneous. Non overloaded channels continue to operate normally. The open-drain diagnostics output indicates overtemperature conditions and open-load in off state.

Table 1. Device summary

Order codes	Package	Packaging
VNI2140J	PowerSSO-12™	Tube
VNI2140JTR		Tape and reel

Table 2. Main features

Type	$V_{\text{demag}}^{(1)}$	$R_{\text{Dson}}^{(1)}$	$I_{\text{out}}^{(1)}$	V_{CC}
VNI2140J	$V_{\text{CC}} - 45 \text{ V}$	0.08Ω	$1 \text{ A}^{(2)}$	45 V

1. Per channel.

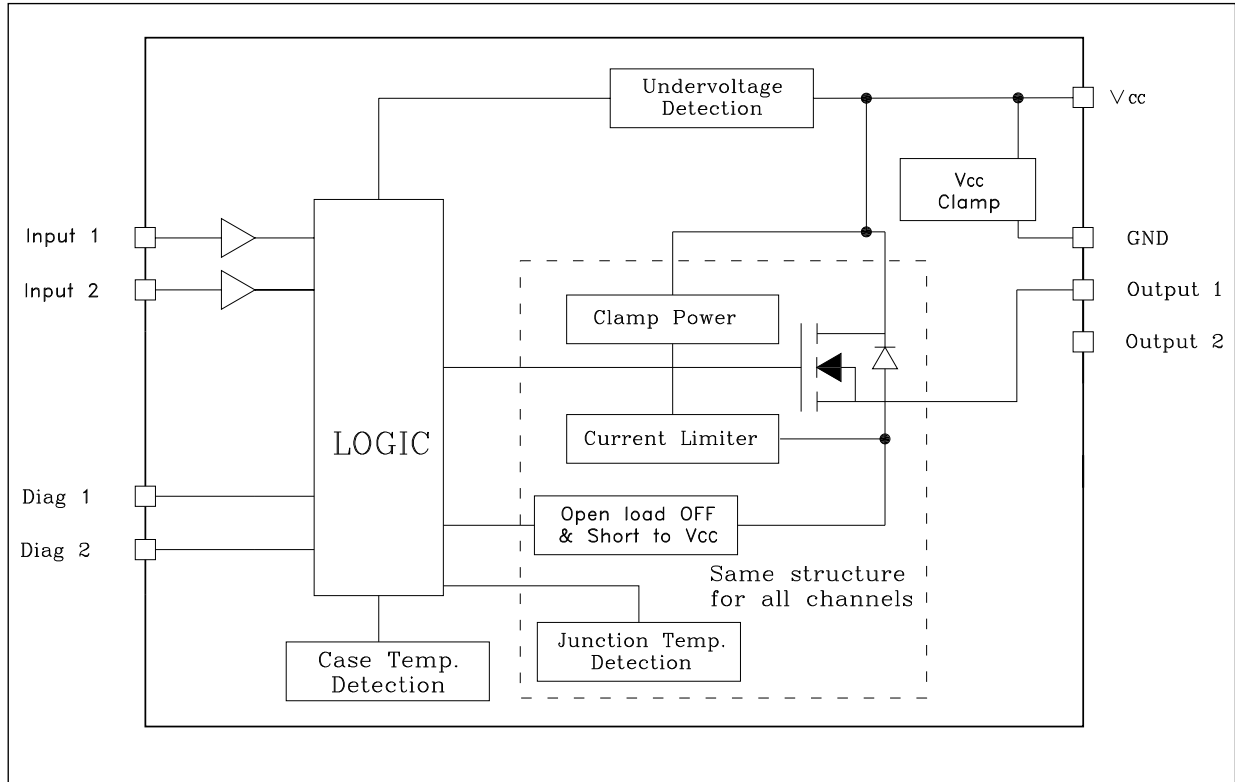
2. Current limitation.

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1 Block diagram

Figure 1. Block diagram



2 Pin connections

Figure 2. Pin connections (top view)

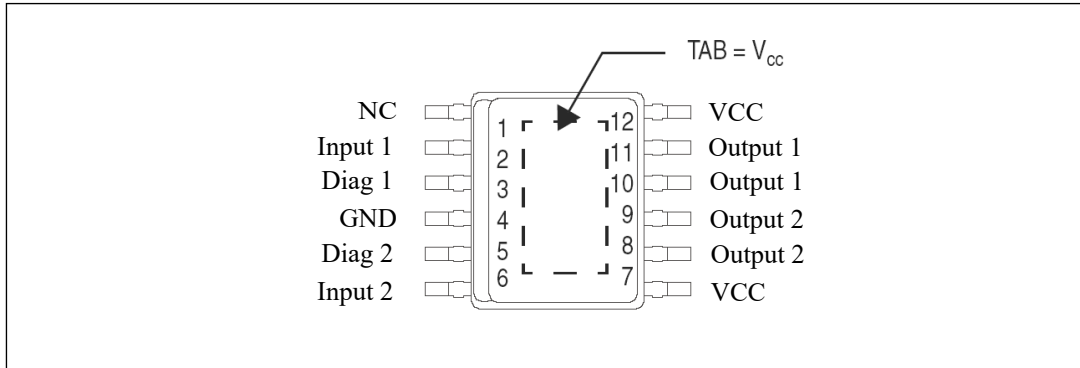


Table 3. Pin description

No.	Name	Description
1	NC	Not connected
2	Input 1	Channel 1 input 3.3 V CMOS/TTL compatible
3	Diag 1	Channel 1 diagnostic in open-drain configuration
4	GND	Device ground connection
5	Diag 2	Channel 2 diagnostic in open-drain configuration
6	Input 2	Channel 2 input 3.3 V CMOS/TTL compatible
7	VCC	Supply voltage
8	Output 2	Channel 2 power stage output, internally protected
9	Output 2	Channel 2 power stage output, internally protected
10	Output 1	Channel 1 power stage output, internally protected
11	Output 1	Channel 1 power stage output, internally protected
12	VCC	Supply voltage
TAB	TAB	Supply voltage

3 Maximum ratings

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Power supply voltage	45	V
$-V_{CC}$	Reverse supply voltage	-0.3	V
I_{GND}	DC ground reverse current	-250	mA
I_{OUT}	Output current (continuous)	Internally limited	A
I_R	Reverse output current (per channel)	-5	A
I_{IN}	Input current (per channel)	± 10	mA
V_{IN}	Input voltage	$+V_{CC}$	V
V_{DIAG}	Diag pin voltage	$+V_{CC}$	V
I_{DIAG}	Diag pin current	± 10	mA
V_{ESD}	Electrostatic discharge (R = 1.5 k Ω ; C = 100 pF)	2000	V
E_{AS}	Single pulse avalanche energy per channel, all channels driven simultaneously at $T_{amb} = 125\text{ }^{\circ}\text{C}$, $I_{OUT} = 1\text{ A}$	300	mJ
P_{TOT}	Power dissipation at $T_c = 25\text{ }^{\circ}\text{C}$	Internally limited	W
T_J	Junction operating temperature	Internally limited	$^{\circ}\text{C}$
T_{STG}	Storage temperature	-55 to 150	$^{\circ}\text{C}$

Thermal data

Table 5. Thermal data

Symbol	Parameter	Value	Unit
$R_{th(JC)}$	Thermal resistance junction to case ⁽¹⁾	Max. 1	$^{\circ}\text{C}/\text{W}$
$R_{th(JA)}$	Thermal resistance junction to ambient ⁽²⁾	Max. See Figure 11 on page 15	$^{\circ}\text{C}/\text{W}$

1. Per channel.

2. When mounted using minimum recommended pad size on FR-4 board.

4 Electrical characteristics

9 V < V_{CC} < 36 V; -40 °C < T_J < 125 °C; unless otherwise specified.

Table 6. Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V _{CC}	Supply voltage		9	-	45	V
R _{DS(ON)}	On-state resistance	I _{OUT} = 0.5 A at T _J = 25 °C I _{OUT} = 0.5 A	-	0.080	0.150	Ω Ω
V _{CLAMP}	Clamp voltage	I _S = 20 mA	45	-	52	V
I _S	Supply current	All channel in off-state On-state with V _{IN} = 5 V (T _J = 125 °C)	-	300 1.9	4	μA mA
I _{LGND}	Output current at turn-off	V _{CC} = V _{DIAG} = V _{IN} = V _{GND} = 24 V, V _{OUT} = 0 V	-	-	1	mA
V _{OUT(OFF)}	Off-state output voltage	V _{IN} = 0 V and I _{OUT} = 0 A	-	-	3	V
I _{OUT(OFF)}	OFF-state output current	V _{IN} = V _{OUT} = 0 V	0	-	5	μA
I _{OUT(OFF1)}		V _{IN} = 0 V; V _{OUT} = 4 V	-35	-	0	μA

Table 7. Timing (V_{CC} = 24 V, R_{LOAD} = 48 Ω)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t _{d(ON)}	Turn-on delay time of output current	I _{OUT} = 0.5 A, resistive load Input rise time < 0.1 μs, T _J = 25 °C	-	8	-	μs
t _r	Rise time of output current	I _{OUT} = 0.5 A, resistive load Input rise time < 0.1 μs, T _J = 25 °C	-	15	-	μs
t _{d(ON)} + t _r	Turn-on response	I _{OUT} = 0.5 A, resistive load Input rise time < 0.1 μs, T _J = 25 °C	-	-	35	μs
t _{d(OFF)}	Turn-off delay time of output current	I _{OUT} = 0.5 A, resistive load Input rise time < 0.1 μs, T _J = 25 °C	-	10	-	μs
t _f	Fall time of output current	I _{OUT} = 0.5 A, resistive load Input rise time < 0.1 μs, T _J = 25 °C	-	7	-	μs
t _{d(OFF)} + t _f	Turn-off response	I _{OUT} = 0.5 A, resistive load Input rise time < 0.1 μs, T _J = 25 °C	-	-	40	μs
t _{DOL}	Delay time for open-load detection	-	-	500	-	μs
dV/dt _(ON)	Turn ON voltage slope	-	-	3	-	V/μs
dV/dt _(off)	Turn OFF voltage slope	-	-	4	-	V/μs

Table 8. Logical input

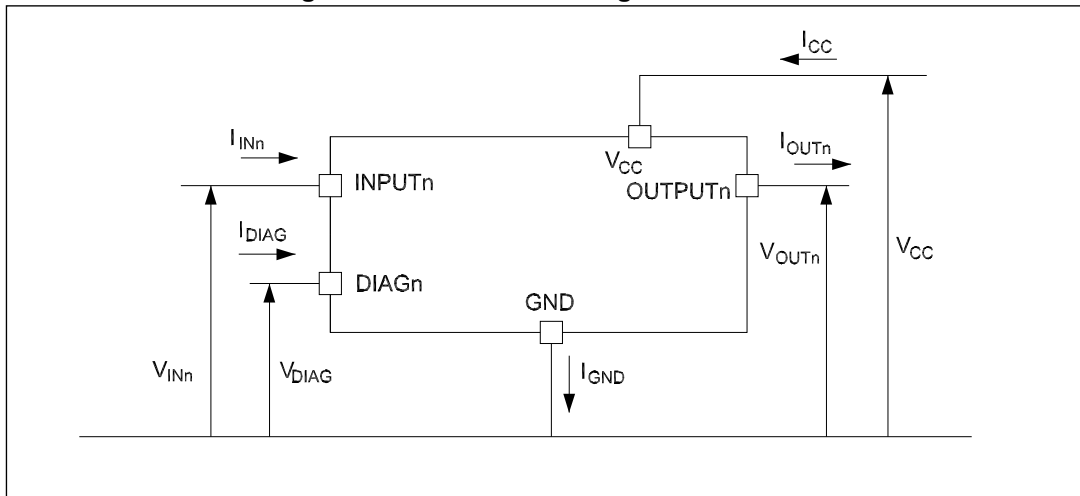
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input low level voltage	-	-	-	0.8	V
V_{IH}	Input high level voltage	-	2.20	-	-	V
$V_{I(HYST)}$	Input hysteresis voltage	-	-	0.15	-	V
I_{IN}	Input current	$V_{IN} = 15\text{ V}$	-	-	10	μA
		$V_{IN} = 36\text{ V}$	-	-	210	

Table 9. Protection and diagnostic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{DIAG}^{(1)}$	Diag voltage output low	$I_{DIAG} = 1.5\text{ mA}$ (fault condition)	-	-	0.6	V
V_{USD}	Undervoltage protection	-	7	-	9	V
V_{USDHYS}	Undervoltage hysteresis	-	0.4	0.5	-	V
I_{LIM}	DC short-circuit current	$V_{CC} = 24\text{ V}; R_{LOAD} < 10\text{ m}\Omega$	1	-	2	A
I_{LDIAG}	Diag leakage current	$V_{CC} = 32\text{ V}$	-	30	-	μA
V_{OL}	Open-load off-state voltage detection threshold	$V_{IN} = 0\text{ V}$	2	3	4	V
T_{TSD}	Junction shutdown temperature	-	150	170	-	$^{\circ}\text{C}$
T_R	Junction reset temperature	-	135	155	200	$^{\circ}\text{C}$
T_{HIST}	Junction thermal hysteresis	-	7	15	-	$^{\circ}\text{C}$
T_{CSD}	Case shutdown temperature	-	125	130	135	$^{\circ}\text{C}$
T_{CR}	Case reset temperature	-	110	-	-	$^{\circ}\text{C}$
T_{CHYST}	Case thermal hysteresis	-	7	15	-	$^{\circ}\text{C}$
V_{demag}	Output voltage at turn-OFF	$I_{OUT} = 0.5\text{ A}; L_{LOAD} \geq 1\text{ mH}$	$V_{CC} - 45$	$V_{CC} - 50$	$V_{CC} - 52$	V

1. Diag determination > 100 ms after the switching edge.

Figure 3. Current and voltage conventions



5 Truth table

Table 10. Truth table

IC condition	INPUTn	OUTPUTn	DIAGn
Normal operation	L	L	H
	H	H	H
Overtemperature	L	L	H
	H	L	L
Undervoltage	L	L	X
	H	L	X
Shorted-load (current limitation)	L	L	H
	H	X	H
Output voltage > V_{OL}	L	Z ⁽¹⁾	L
	H	H	H
Short to V_{CC}	L	H	L
	H	H	H

1. Z = depending on the external circuit.

6 Switching waveforms

Figure 4. Switching waveforms

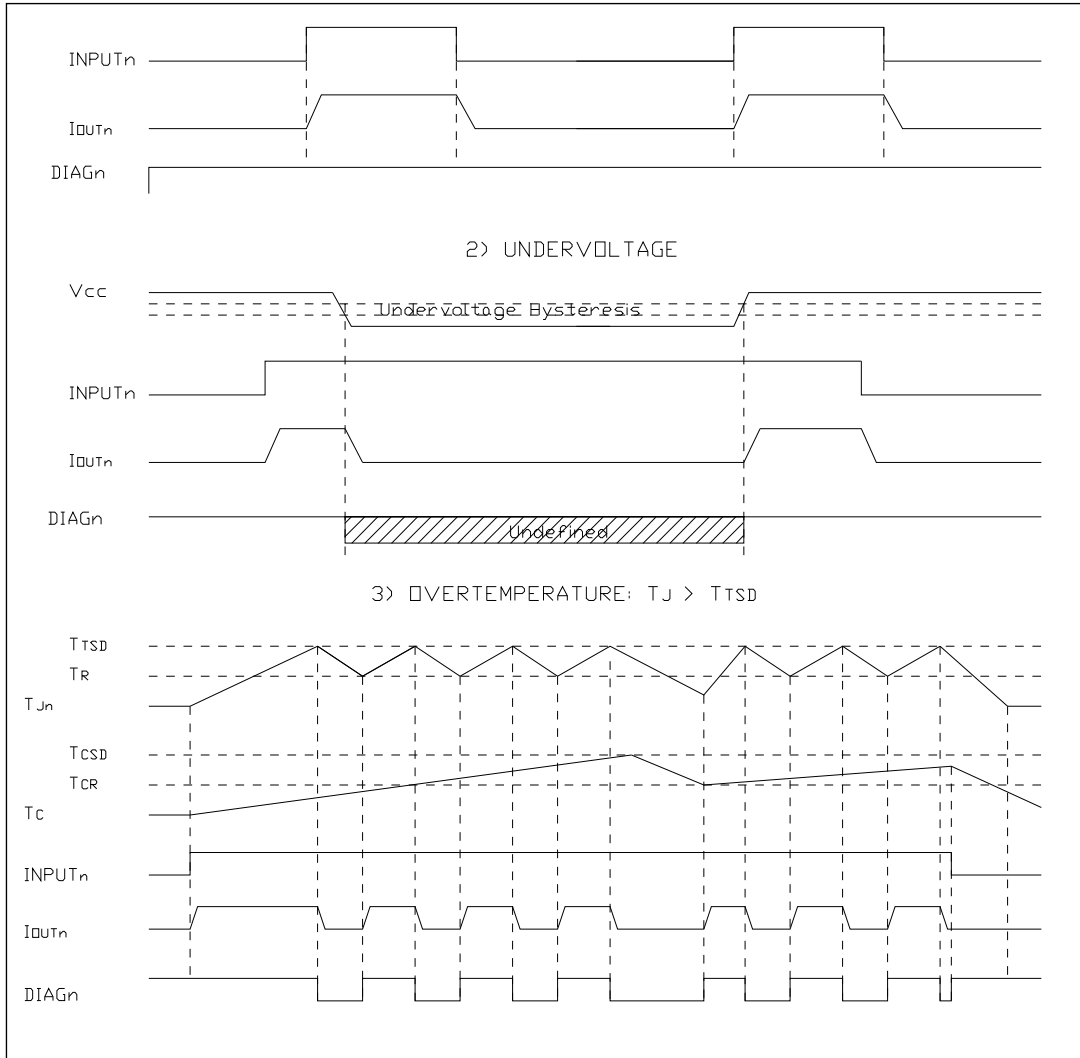


Figure 5. Switching waveforms (continued)

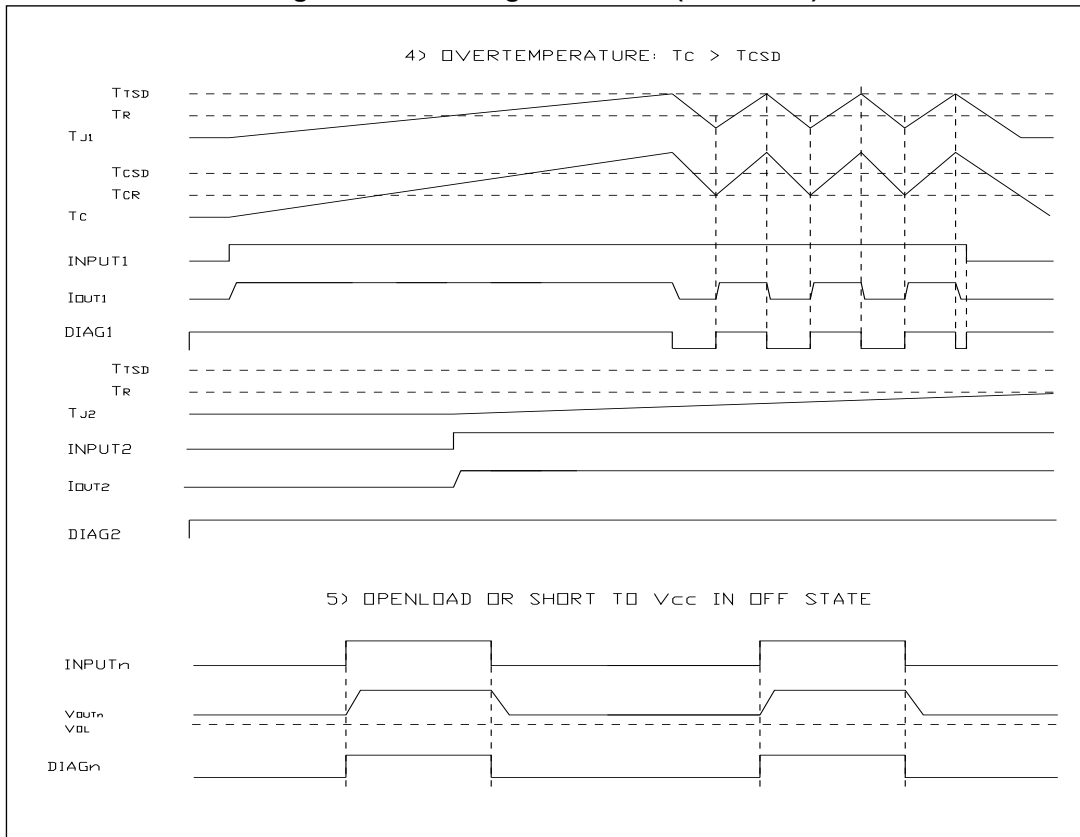


Figure 6. Switching parameter test conditions

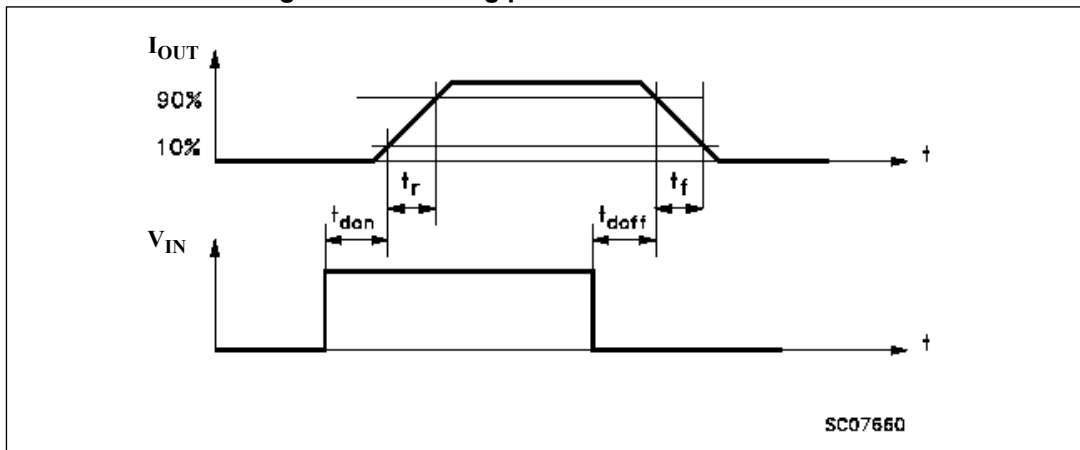
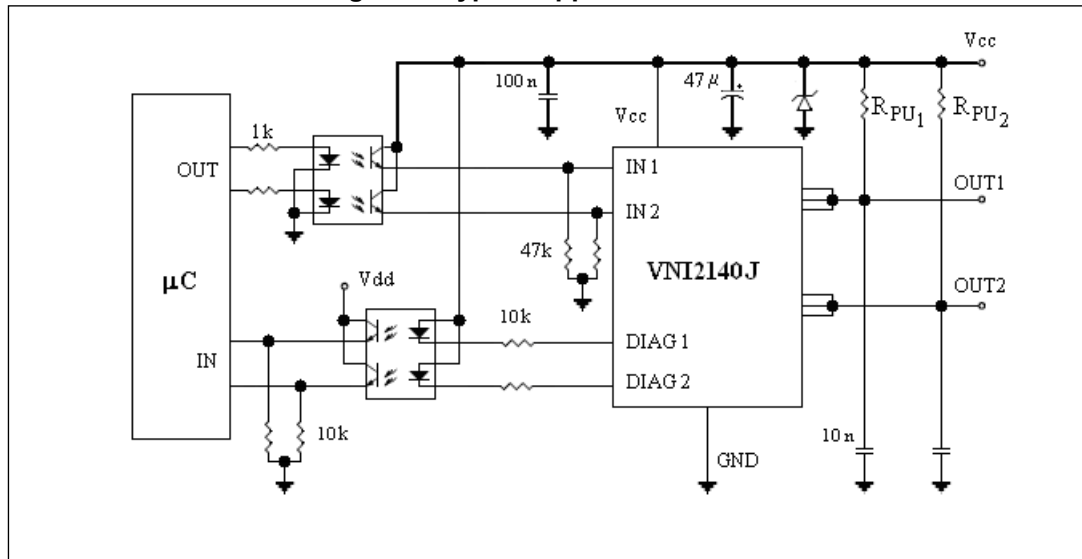


Figure 7. Typical application circuit



7 Open-load

In order to detect the open-load fault a pull-up resistor must be connected between the V_{CC} line and the output pin.

In a normal condition a current flows through the network made up of a pull-up resistor and a load. The voltage across the load is less than V_{OLMIN} ; so the diag pin is kept high.

This is the result in the condition:

Equation 1

$$V_{CC} \frac{R_{LOAD}}{R_{LOAD} + R_{PU}} < V_{OLMIN}$$

or

Equation 2

$$\left(\frac{V_{CC}}{V_{OLMIN}} - 1 \right) \cdot R_{LOAD} < R_{PU}$$

When a open-load event occurs the voltage on the output pin rises to a value higher than V_{OLMAX} (depending on the pull-up resistor). The diag pin will go down.

This result in the condition:

Equation 3

$$R_{PU} < \frac{V_{CC} - V_{OLMAX}}{|I_{OUT(OFF1)MIN}|}$$

Figure 8. Open-load detection

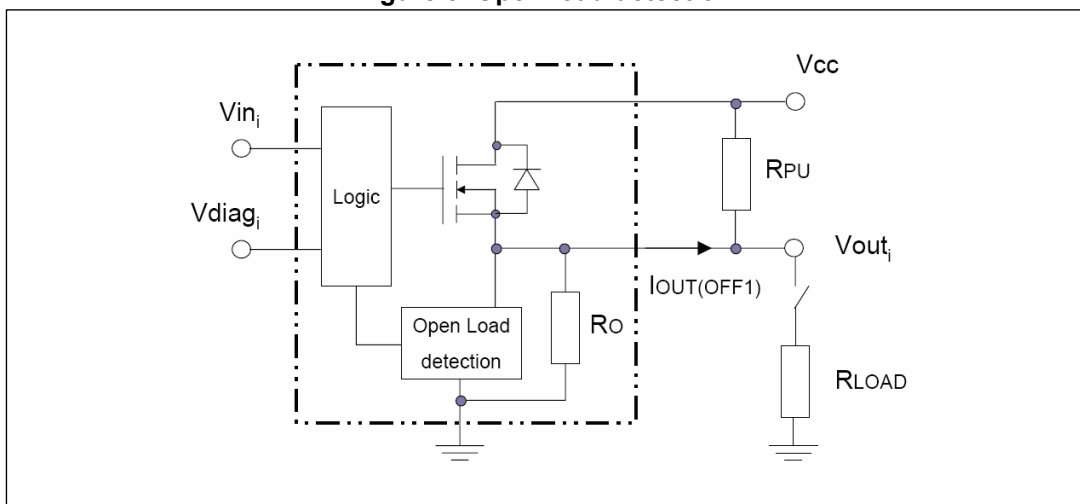
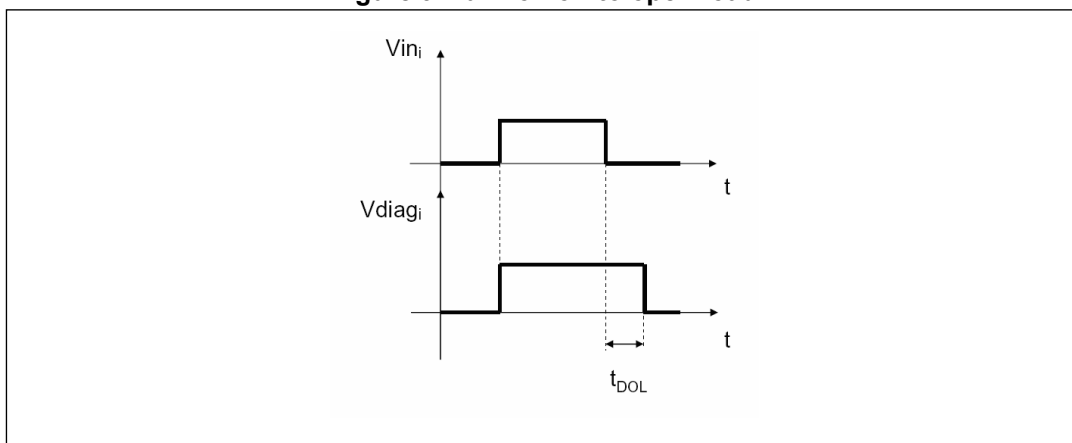


Figure 9. Turn-on/off to open-load



8 Package and PCB thermal data

Figure 10. PowerSSO-12 PC board

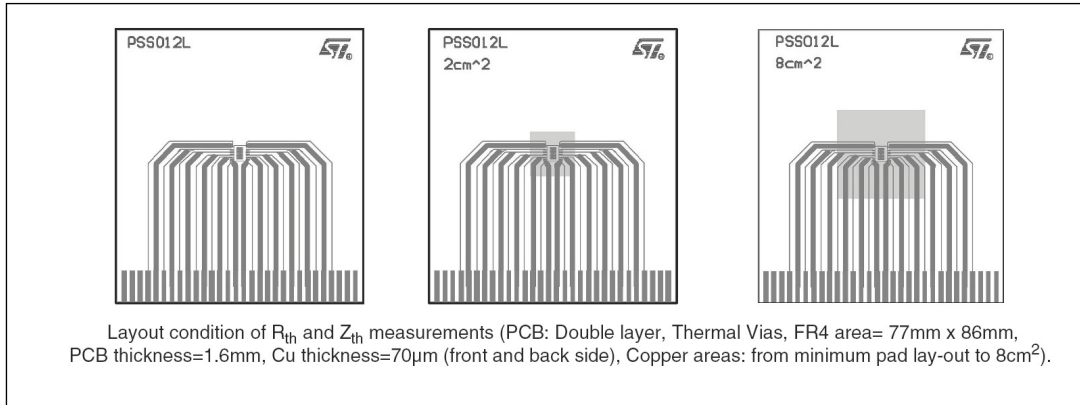


Figure 11. R_{thJA} vs PCB copper area in open box free air condition

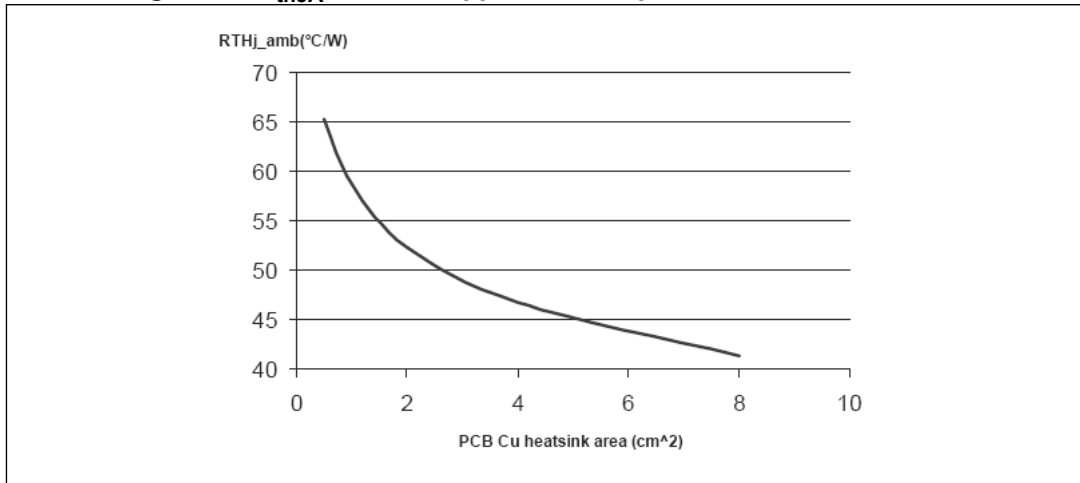
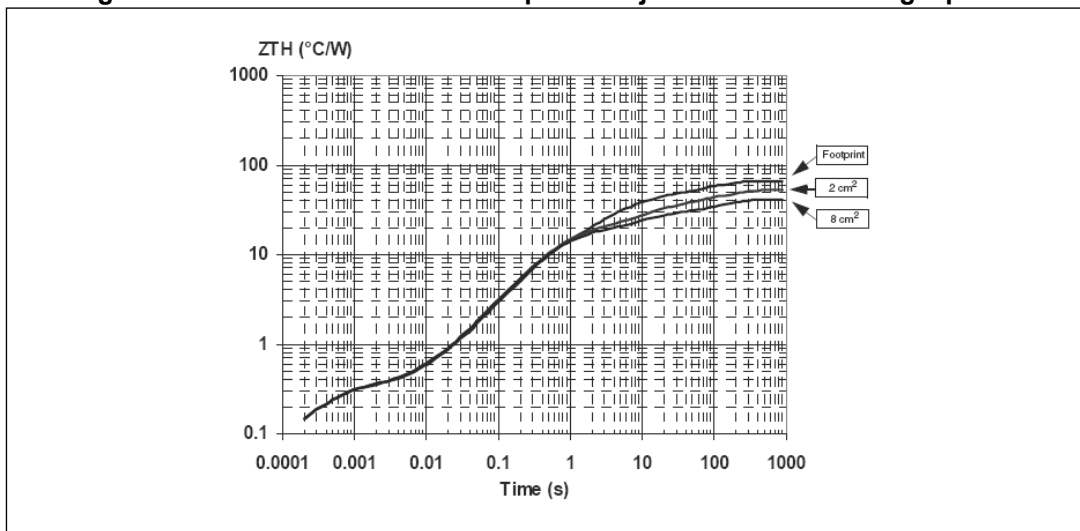


Figure 12. PowerSSO-12 thermal Impedance junction ambient single pulse



Pulse calculation formula

Equation 4

$$Z_{TH\delta} = R_{TH} \times \delta + Z_{THtp} (1 - \delta)$$

where $\delta = t_p/T$

Figure 13. Thermal fitting model of a double channel HSD in PowerSSO-12

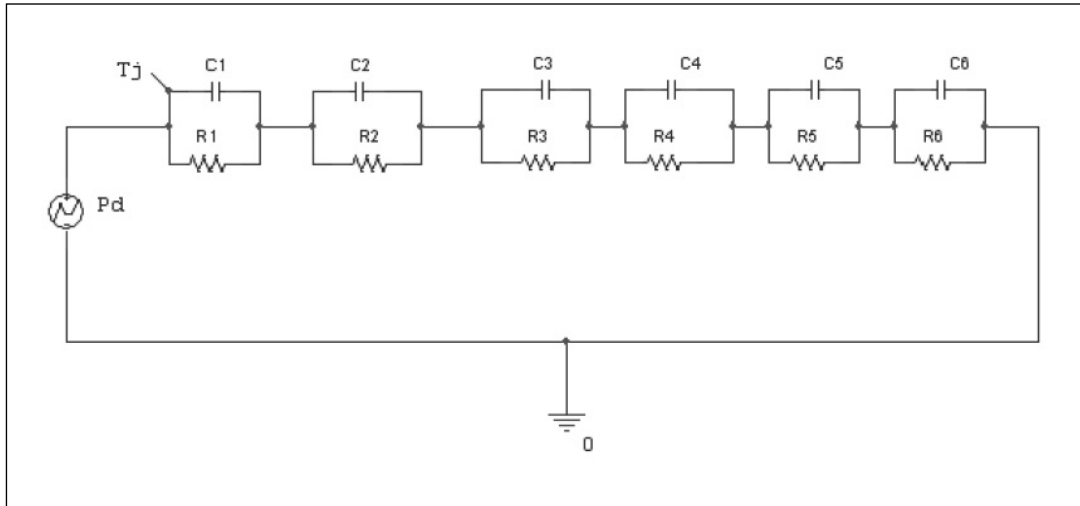


Table 11. Thermal parameter

Area/island (cm ²)	Footprint	2	8
R1 (°C/W)	0.1	-	-
R2 (°C/W)	0.2	-	-
R3 (°C/W)	7	-	-
R4 (°C/W)	10	10	9
R5 (°C/W)	22	15	10
R6 (°C/W)	26	20	15
C1 (W.s/°C)	0.0001	-	-
C2 (W.s/°C)	0.002	-	-
C3 (W.s/°C)	0.05	-	-
C4 (W.s/°C)	0.2	0.1	0.1
C5 (W.s/°C)	0.27	0.8	1
C6 (W.s/°C)	3	6	9

9 Reverse polarity protection

Reverse polarity protection can be implemented on board using two different solutions:

1. Placing a resistor (R_{GND}) between IC GND pin and load GND.
2. Placing a diode between IC GND pin and load GND.

If option 1 is selected, the minimum resistance value has to be selected according to the following equation:

Equation 5

$$R_{GND} \geq V_{CC} / I_{GNDcc}$$

where I_{GNDcc} is the DC reverse ground pin current and can be found in [Section 3: Maximum ratings](#) of this datasheet.

Power dissipated by R_{GND} during reverse polarity situations is:

Equation 6

$$P_D = (V_{CC})^2 / R_{GND}$$

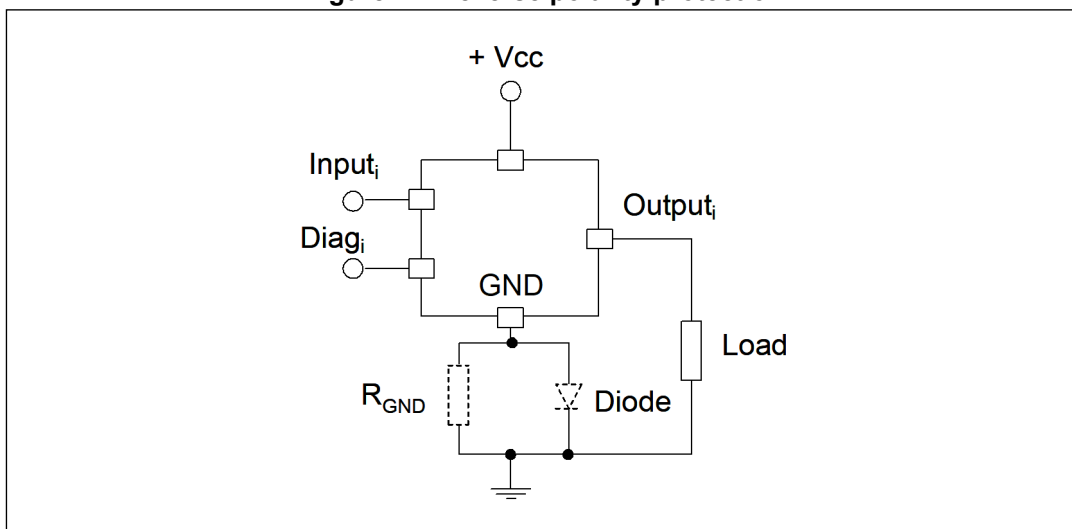
If option 2 is selected, the diode has to be chosen by taking into account $V_{RRM} > |V_{CC}|$ and its power dissipation capability:

Equation 7

$$P_D \geq I_S * V_F$$

*Note: In normal operation (no reverse polarity), there is a voltage drop (ΔV) between GND of the device and GND of the system. Using option 1, $\Delta V = R_{gnd} * I_{cc}$. Using option 2, $\Delta V = V_F @ (I_F)$.*

Figure 14. Reverse polarity protection



10 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

10.1 PowerSSO-12™ package information

Figure 15. PowerSSO-12™ package outline

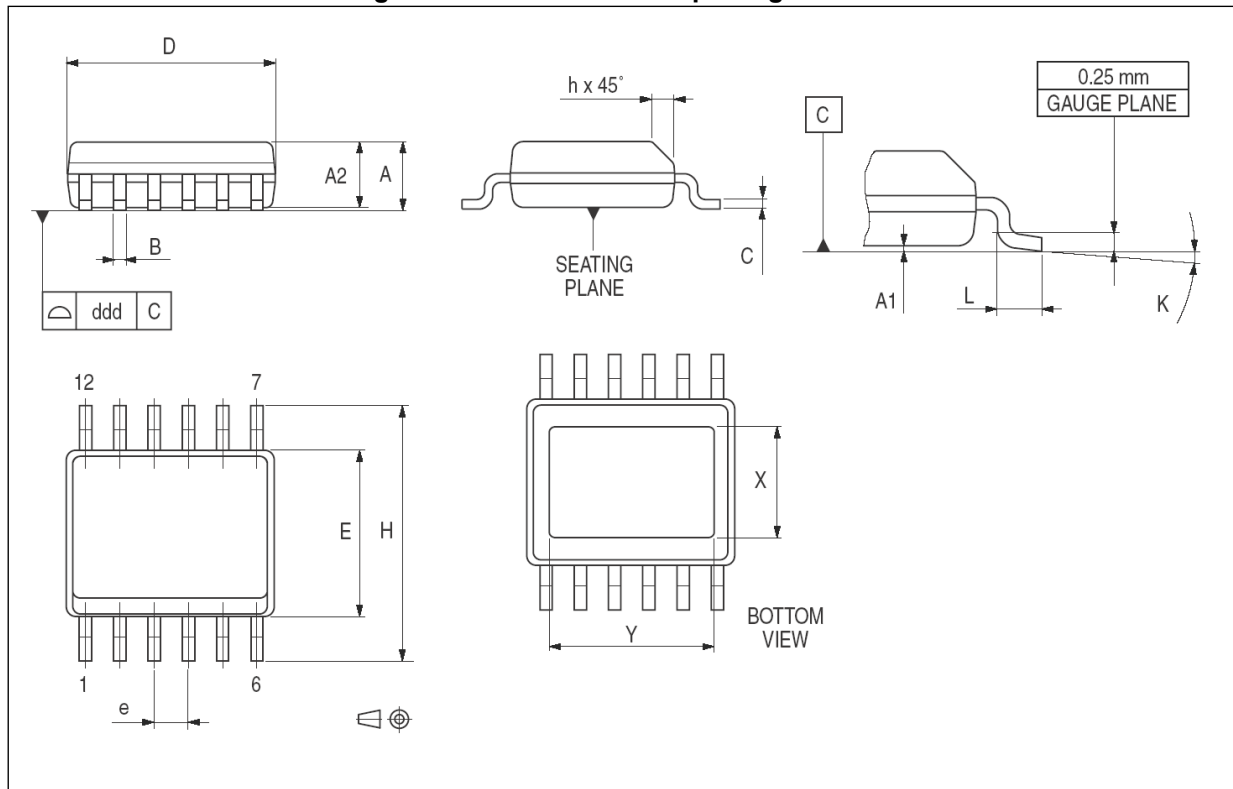


Table 12. PowerSSO-12™ mechanical data

Symbol	Dimensions (mm)		
	Min.	Typ.	Max.
A	1.250	-	1.620
A1	0.000	-	0.100
A2	1.100	-	1.650
B	0.230	-	0.410
C	0.190	-	0.250
D	4.800	-	5.000
E	3.800	-	4.000
e	-	0.800	-
H	5.800	-	6.200
h	0.250	-	0.500
L	0.400	-	1.270
k	0°	-	8°
X	1.900	-	2.500
Y	3.600	-	4.200
ddd	-	-	0.100

Figure 16. PowerSSO-12™ tube shipment (no suffix)

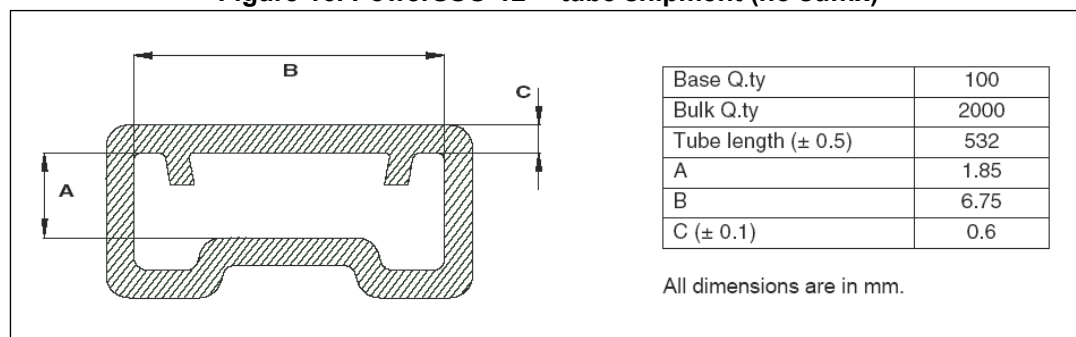


Figure 17. PowerSSO-12™ tape and reel shipment (suffix “TR”)

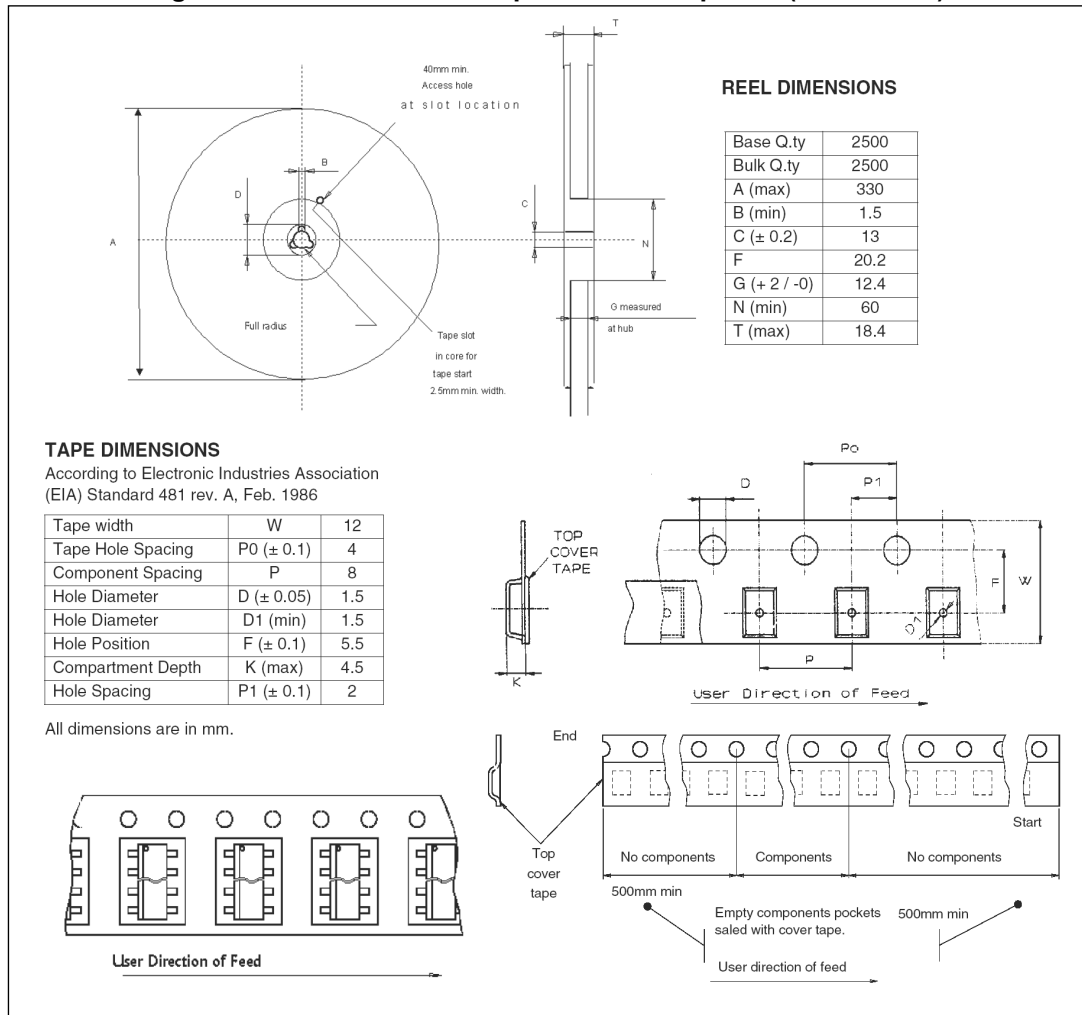
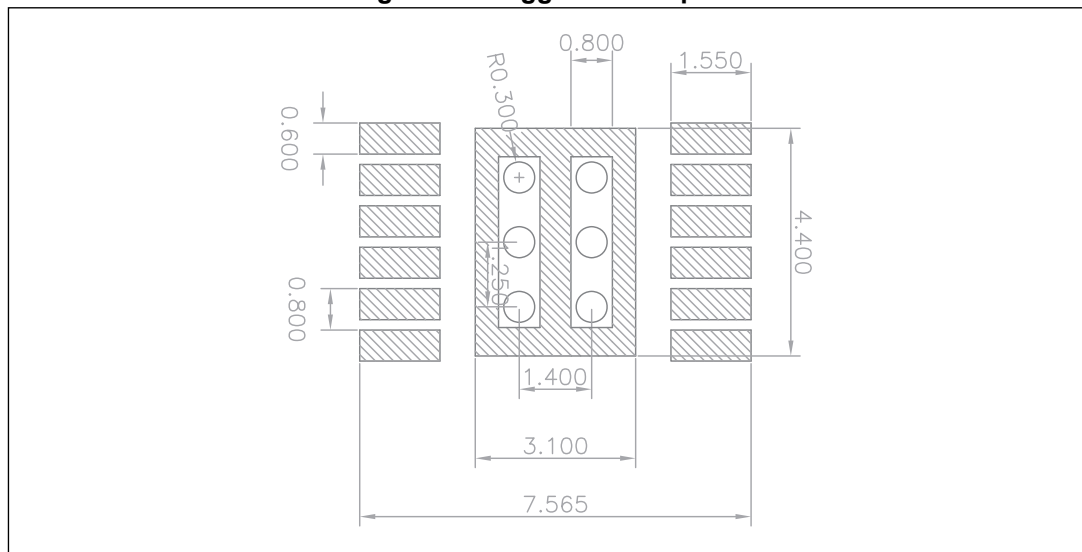


Figure 18. Suggested footprint



11 Revision history

Table 13. Document revision history

Date	Revision	Changes
16-Dec-2008	1	Initial release
29-Apr-2009	2	Updated <i>Table 5 on page 6</i>
03-Jul-2009	3	Updated features in coverpage and <i>Table 5 on page 6</i>
27-Aug-2009	4	Updated <i>Section 9: Reverse polarity protection</i>
25-Mar-2010	5	Updated Coverpage and <i>Table 4 on page 5</i>
26-Apr-2010	6	Updated <i>Table 5 on page 6</i>
21-Jul-2010	7	Updated <i>Table 8 on page 7</i>
15-Nov-2011	8	Updated <i>Figure 18 on page 21</i>
09-Nov-2017	9	Updated <i>Table 4 on page 5</i> and <i>Table 7 on page 6</i> . Minor modifications throughout document.
10-Dec-2019	10	Updated <i>Section 9: Reverse polarity protection</i>

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